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EVALUATION OF METHODS TO LEAK TEST SEALED RADIATION SOURCES

by

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Research report

EVALUATION OF METHODS TO LEAK TEST SEALED RADIATION SOURCES

A research report prepared by N.D. Arbeau and C.K. Scott, principal investigators for Atantic Nuclear Services., under contract to the Atomic Energy Control Board.

ABSTRACT

The methods for the leak testing of sealed radiation sources were reviewed. One hundred and thirty-one equipment vendors were surveyed to identify commercially available leak test instruments. The equipment is summarized in tabular form by radiation type and detector type for easy reference. The radiation characteristics of the licensed sources were reviewed and summarized in a format that can be used to select the most suitable detection method. A test kit is proposed for use by inspectors when verifying a licensee's test procedures. The general elements of leak test procedures are discussed.

RÉSUMÉ

Les méthodes de contrôle d'étanchéité des sources de rayonnement scellées ont été analysées. On a effectué un sondage auprès de cent trente et un vendeurs de matériel dans le but d'identifier des instruments de contrôle d'étanchéité qui seraient disponibles sur une base commerciale. Les appareils sont regroupés dans des tableaux par type de rayonnement et de détecteur de façon à faciliter la consultation. Les caractéristiques de rayonnement des sources autorisées ont été étudiées et résumées sous un format pouvant être utilisé pour choisir la méthode de détection la plus convenable. On propose une trousse d'essai aux inspecteurs qui vérifient les méthodes de contrôle utilisées par les titulaires de permis. Les principaux éléments des méthodes de contrôle d'étanchéité sont expliqués.

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TABLE OF CONTENTS

		Page
1.0	Introduction	1
	1.1 Definitions	3
2.0	Radiation Detection Systems	5
	2.1 Types of Radiation	5
	2.2 Radiation Detectors	6
	2.2.1 Detectors	6
	2.2.1.1 Ionization Detectors	6
	2.2.1.2 Scintillation Counters	10
	2.2.1.3 Semi-Conductor Detectors	11
	2.2.1.4 Photographic Emulsions	11
	2.2.1.5 Dielectric Detectors	12
	2.2.1.6 Summary of Detector Applications	12
	2.2.2 Counting Systems	12
	2.2.2.1 Scalers	12
	2.2.2.2 Ratemeters	12
	2.2.2.3 Discriminators	12
	2.2.2.4 Pulse-Height Analyzers	15
	2.3 General Instrument Characteristics	15
	2.3.1 Sensitivity	15
	2.3.2 Resolution	15
	2.3.3 Response Time	16
	2.3.4 Efficiency	16
3.0	Commercially Available Instruments	18
	3.1 Survey of vendors	18
4.0	Radiation Characteristics of Sealed Sources	22
	4.1 The Leak Test Kit	29
5.0	Procedures for Leak Testing	32
	5.1 Test Objective	32
	5.2 Selection of Equipment	32
	5.3 Test Procedures	33
	5.4 Staff Training	34
	5.5 Quality Assurance	34
6.0	Summary	35
7.0	References	36
8.0	Bibliography	37

APPENDIX A ..... Vendor Survey

APPENDIX B ..... Commercially Available Radiation Detection Instruments

APPENDIX C ..... Survey of Companies Performing Leak Test Analysis

1.0 Introduction

Compliance Services and Laboratories Division (CSLD) inspectors of the Atomic Energy Control Board (AECB) routinely monitor a licensee's compliance with the licence condition that leak tests be made on sealed sources. Industrial activities and instruments using sealed radioactive sources include the following:

(a) teletherapy machines

(b) brachytherapy devices

(c) irradiators

(d) nuclear guages for density, volume or moisture measurements

(e) gas chromatograph electron capture detectors

(f) industrial radiography devices

A list of radionuclides in sealed sources that may require testing is given in Table 1.

The AECB intends to apply regulatory standards to the test procedures being used by licensees. In support of this program, Atlantic Nuclear undertook an evaluation of methods to leak test sealed sources.

The objective of the study was to produce a technical reference document which serves the following two purposes.

(i) describe the techniques that are suited for analyzing the radioisotope contamination on wipe samples.

(ii) describe a kit of radioisotope specimens that can be used to verify the accuracy of procedures used to test wipes for radioactive contamination.

The instruments and procedures must be such that 200 Bq of any of the radioisotopes in Table 1 can be detected on a wipe.

The study was confined to an evaluation of the detection procedures and instruments. The procedures for physically obtaining the test wipe were not considered to be part of the project.

The types of radiation to be detected are described in Section 2 along with the physical principles used to detect the different types of radiation. Also, the different types of commercially available detectors are described together with instrument response characteristics.

TABLE 1 LIST OF SEALED SOURCES REQUIRING LEAK TESTING

RADIOISOTOPE	HALF LIFE	RADIATION EMITTED
C-14	5600 y	B-
Fe-55	2.6 y	EC (Bremsstrahlung Q = .22 Mev)
Co-57	270 d	EC/Y
Co-60	5.2 y	B-/Y
Ni-63	125 y	B-
Sr-90	28 y	B-
Ru-106	1.0 y	B-
Cd-109	470 d	EC/Y
I -125	60 d	EC/Y
Cs-137	27 y	B-/Y
Ce-144	285 d	B-/Y
Pm-147	2.6 y	B-
Gd-153	236 d	EC/Y
Yb-169	32 d	EC/Y
Ta-182	115 d	B-/Y
Ir-192	74 d	EC/Y (4%) B-/Y (96%)
Tl-204	3.6 y	B- (98%) EC (2%)
Pb-210	19 y	B-/Y
Ra-226	1622 y	α/Y
Pu-238	86 y	α/Y
Am-241	460 y	α/Y
Cm-244	18 y	α/Y

In partial fulfilment of the project's objectives Atlantic Nuclear undertook a mail survey of instrument vendors to identify commercially available instruments for leak testing. The acceptance criterion for instruments is that they be able to detect 0.2 kBq of a radioisotope from Table 1 with a 90% confidence level. The results of the survey are reported in Section 3. Those detectors that meet the 0.2 kBq detection limit are tabulated. Since not all vendors responded, the listing cannot be considered exhaustive.

In Section 4 the radiation characteristics of the radionuclides from Table 1 are summarized. The radiation type, energies and intensities from a 200 Bq source are tabulated. This information can be used to select a suitable test procedure for any of the radionuclides. A test kit of only a few nuclides that will test the procedures being used for any of the radioisotopes is also given.

A licensee will follow a standard procedure to monitor the radioactive sources for leaks. The procedure must be capable of detecting the radiation from the leaking radioisotope at the level of 0.2 kBq. Each licensee will have to have specific procedures for using his detection system to test for a specific radioisotope on the test wipe. There are several general practices that should be included in all test procedures. The development of procedures is discussed in Section 5.

The report is concluded in Section 6 with a summary of the findings.

1.1 Definitions

The following terminology is used in the report.

Detector/Detection System - instrumentation for detecting radioactive material and comprising both the detector and electronics.

Detector - the part of the detection system that interacts with the radiation present.

Leak Test Analysis - a procedure used to determine the physical integrity of a sealed radioactive source.

Leak Test Sample - a material such as cotton swabs or filter papers, used in the wiping of a sealed radioactive source.

Test Wipe - same as Leak Test Sample.

Sealed Source - a radioactive source sealed in a capsule or having a bonded cover, the capsule or cover being strong enough to prevent contact with and dispersion of the radioactive material under the conditions of use and wear for which it was designed.

Sensitivity - the ratio of the change in output magnitude to the change of input which causes it, after the steady state has been reached. It is expressed as a ratio with the units of measurement of the two quantities stated. The ratio is constant for a linear device. For a non-linear device the applicable input level must be stated.

Test Kit - a kit comprising a set of radioactive samples to be used to verify that a specific leak test procedure can detect a leak at the 200 Bq limit of detectability.

2.0 Radiation Detection Systems

2.1 Types of Radiation

Nuclear radiation is a particle or electromagnetic wave which will interact with matter producing one of the following results that can be detected:

(a) photon emission (light - scintillation)

(b) electron-ion pair production (ionization)

(c) electron-hole production (semi-conductor solids)

The design of radiation detection systems is based on the measurement of energy released in one of the above interactions.

The four types of radiation to be detected in leak tests for the radionuclides in Table 1 are the following:

(a) Alpha particles

An alpha particle is a helium nucleus comprised of two protons and two neutrons that is spontaneously emitted from the atomic nucleus. Alphas have a range of a few cm in air. This short range is an important consideration in preparing test procedures.

(b) Beta particles

Beta particles are electrons (or positrons) emitted from the nucleus as the result of neutron to proton transformation. Beta particles usually have little penetrating power and can easily be stopped by paper, wood or plastic.

(c) Gamma rays

Gamma rays are electromagnetic radiation emitted from an atomic nucleus. They have an energy range of keV to MeV. Their interaction length in matter is much longer than for the charged alpha or beta particles. As a result gamma rays readily penetrate a small thickness of material.

(d) X-rays

X-rays are electromagnetic radiation produced by atomic electron transitions or by changes in velocity of high speed electrons (Bremsstralung). The energy is usually lower than that of gamma rays from nuclear transitions. For the radioisotopes of interest here, x-rays are produced as a result of orbital electron capture by a proton in the nucleus.

Details of the types of radiation and their interaction with matter can be found in standard texts such as listed in the Bibliography, Section 8.

2.2 Detection Systems

Any detection system can be divided into two elements:

(a) The detector or the material that interacts with the radiation to produces a measureable signal.

(b) The electronic circuits which measure the amount of energy deposited in the detector.

A schematic of a typical radiation detection system is shown in Figure 1.

2.2.1 Detectors

The different types of detectors that have been developed for detecting radiation are summarized in Table 2 and they are briefly described below.

2.2.1.1 Ionization Detectors

There are three types of detectors that use ionization of a gas to detect radiation. The operating principles are illustrated in Figure 2 and described below.

(1) Ion Chambers

An ion chamber consists of an anode and cathode separated by a gas. Argon or air are common gases used. The radiation interacting with the gas produces ion pairs that are collected on the electrodes producing an electrical signal. Ion chambers are not sensitive to low levels of radioactivity and, in general, cannot detect 200 Bq.

(2) Proportional Counters

A proportional counter collects ion pairs on electrodes; however, the anode voltage is increased above that used in ion chambers so that the ionized electrons are accelerated to produce secondary ionization which amplifies the signal. Proportional counters can be used for low energy x-ray or gamma ray spectrometry (up to 20 keV), alpha, beta and neutron detection.

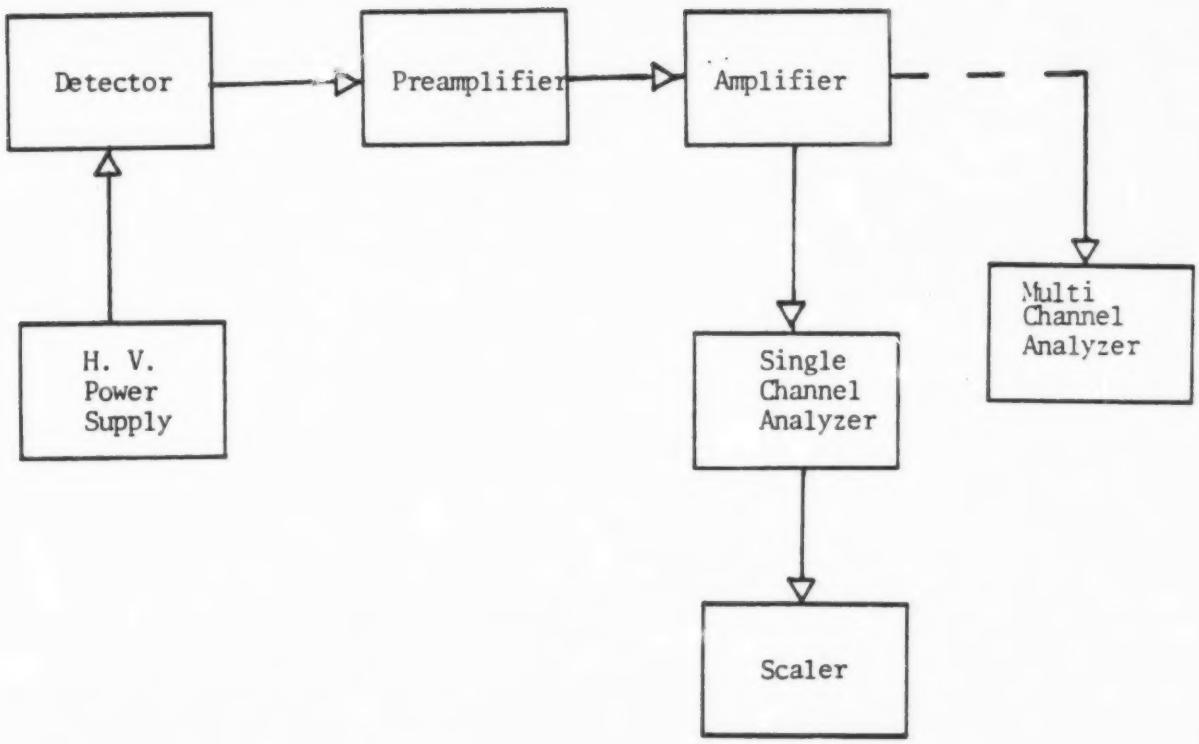

Figure 1. A Typical Radiation Detection System

TABLE 2 TYPES OF RADIATION DETECTORS (REF 1)

NAME	TYPE	PRIMARY INTERACTION	MEDIUM	MODE OF USE
Ionization chamber	Signal	Ionization	Gas	Primary ionization measured as individual current pulses or as a mean current
Proportional counter Geiger counter	Signal	Ionization	Gas	Primary ionization increased by gas multiplication and individual current pulses amplified electronically as necessary
Scintillation counter	Signal	Excitation of electronic levels and emission of photons on return to ground states	Gas, Liquid, and Solid	Light pulses measured with photomultiplier tube
Semi-conductor counter	Signal	Production of electron-hole pairs	Solid	Current pulses amplified electronically
Photographic emulsion (Film)	Track (Single or multiple)	Ionization	Solid	After development process single tracks observed and measured optically, or mean density measured
Dielectric detector	Track	Ionization	Solid	Tracks developed by etching of the dielectric material

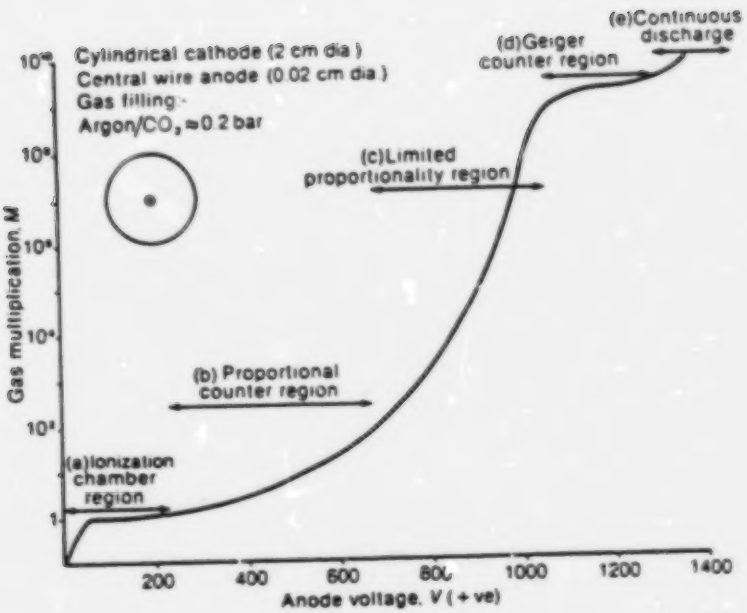

Figure 2. Example of Operating Regions for a Gas Ionization Detector (Ref. 1)

(3) Geiger-Mueller (GM) Counters

In a GM counter the anode voltage is at a higher level (Figure 1) where the gas amplification of the primary ionizing radiation becomes constant and the signal independent of the energy of primary ionizing rays. These instruments are used as particle detectors. Contami-nation probes usually have a thin mica window (<40 mg/cm^2) enabling the detection of beta as well as gamma radiation. They are designed only to monitor the number of ionizing events occuring per second in the detector and are not as accurate as other detectors at high count rates.

GM tubes have been designed to detect alpha particles. Detector windows have to be 1-10 mg/cm^2 in thickness and the alpha particle energies to be detected greater than 3 MeV.

2.2.1.2 Scintillation Counters

Many substances will produce light (scintillate) when exposed to radiation. The radiation excites electronic states and the photons are emitted as they de-excite. This process has allowed the development of instrumentation for the detection of alpha, beta and gamma radiation. The light emitted in a phosphor is detected by a photomultiplier tube (PMT) which converts the light emitted into an electric current. The scintillator can be either a solid or a liquid phosphor.

(1) Solid Phosphors

Solid inorganic and organic crystals can be used for the detection of radiation. Sodium iodide (NaI) with thallium (Tl) impurities is a common crystal used in gamma spectroscopy. Zinc sulphide is often used for alpha detection.

(2) Liquid Scintillation Counting

Liquid scintillation is commonly used for the detection of low energy beta emitters such as H-3 and C-14. It is less commonly used for the detection of alpha and gamma rays. The radioactive material has to be dissolved into the liquid solvent which is commonly an organic chemical. The radiation energy is deposited in the solvent and emitted as violet or ultra-violet radiation which can be detected.

2.2.1.3 Semi-conductor Detectors

Semi-conductor detectors can be considered to be ion chambers with a solid as a medium instead of a gas. Electron-hole pairs are created by the radiation and collected. The advantages of a semi-conductor detector over a scintillator or gas filled detector are:

(1) a convenient and compact size

(2) a fast rise time of output signals

(3) linear response over a wide energy range

(4) excellent energy resolution

(5) diversity in sensitivity depth, area and geometry to fit the required application.

The two common materials used in semi-conductor detectors are germanium and silicon:

(a) Silicon Surface Barrier Detector

Silicon surface barrier detectors are used for heavy charged particle detection. They consist of a thin p-type layer on a high purity n-type silicon wafer. The ionizing radiation produces electron-hole pairs which are collected. Connection to a scaler and multi-channel analyzer allows for alpha spectroscopy. This type of detector can also be used for x-ray spectrometry and beta particle detection.

(b) Germanium Detectors

Germanium detectors are more efficient and provide better energy resolution than silicon surface barrier detectors for the detection of gamma radiation. Combined with a multi-channel analyzer and scaler, the detector is used for high resolution gamma spectroscopy. They have to be operated at liquid nitrogen temperatures.

2.2.1.4 Photographic Emulsions

Photographic film can be used to detect various wavelengths of electromagnetic radiation. For example, film is used to detect x-rays in medical applications and gamma rays in industrial radiography. The density of exposure of the film determines the amount of radiation intercepted in a given time interval. Before the development of thermoluminescent dosimeters (TLD's), film was employed in the measurement of doses of radiation received by individuals.

Co-60 and Ir-192 are used in industrial radiography. Radiography film has been shown to be sensitive to contamination levels of activity (Ref. 6). By placing cotton swabs used for leak testing between two strips of radiography film for 24 hours activity levels as low as 74 Bq (2 nanocuries) can be detected.

2.2.1.5 Dielectric Detectors

Dielectric 'track-etch' detectors are employed in the detection of alpha particles. The alpha particle penetrates a plastic strip leaving behind a microscopic track that can be etched by chemical means. Track-etch detectors have been developed that are sensitive to picocurie (mBq) levels of radon. Counting the number of tracks for a given exposure interval gives the alpha emission rate. This process has been applied to measuring radon concentrations in mines and residences.

2.2.1.6 Summary of Detector Applications

Table 3 summarizes the application of the different detectors to the detection of different radiation types over a range of energies.

2.2.2 Counting Systems

Scalers, ratemeters, discriminators and/or pulse height analyzers are used to convert the signal from the detector into a radiation measurement. These components are described briefly below.

2.2.2.1 Scalers

A scaler is a device which records the total number of pulses or counts that occurred in a detector. This is displayed as a number of counts for an elapsed time interval.

2.2.2.2 Ratemeters

A ratemeter is a device which records the rate at which pulses or counts are occurring in a detector. This is displayed as counts per second or counts per minute.

2.2.2.3 Discriminators

A discriminator blocks out pulses which are not of a preset magnitude. Only pulses from the amplifiers above this threshold will be counted by a ratemeter or scaler.

TABLE 3 SUMMARY OF APPLICATIONS OF RADIATION DETECTORS (Ref. 2)

DETECTOR	RADIATION TYPE	ENERGY RANGE	OVERALL EFFICIENCY
Ionization Chamber	Alpha	All-counting & spectroscopy	High
	Beta	All energies <3 Mev	Medium
	Gamma	All	<.1%
	X-rays	Common in radiological safety work	Window thickness dependent
Proportional Counters	Alpha	All - spectroscopy	Window thickness dependent, high
	Beta & Electrons	Detects all energies <3 Mev: spectroscopy with low energy <200 Kev	Medium
	Gamma	All energies	<1%
	X-rays	Energy discrimination spectra, radiological safety and diffraction studies	
G-M Counters	Alpha	Insensitive to energy	Medium
	Beta & Electrons	Insenitive to energy <3 Mev	Medium
	Gamma	All energies through a secondary process	<1%
	X-rays	Common survey equipment	Window thickness dependent
Scintillation		Can do spectroscopic work with all scintillators with moderate resolutions.	
(a) Inorganic	Alpha	All energies - ZnS. No energy discrimination	High
	Beta	Low energies - CsI(Tl)	Medium
	Gamma	All energies - NaI(Tl), CsI	Medium
	Neutrons	Thermal - LiI(Eu)	Medium
	X-rays	Thin (1-3mm) NaI(Tl) - ultra thin beryllium window	High

TABLE 3 SUMMARY OF APPLICATIONS OF RADIATION DETECTORS (Continued)

DETECTOR	RADIATION TYPE	ENERGY RANGE	OVERALL EFFICIENCY
Scintillation			
(b) Organic	Alpha	All - anthracene	Medium
	Beta & Electrons	All - anthracene, stilbene, plastics, liquids	Medium
	Gamma	All - plastics	Poor
	Neutrons	Plastic, liquids	Low
Semi-Conductors		Can do spectroscopic work with resolution that is at least a factor of 10 better than for scintillators	
	Alpha	All energies with good resolution - surface barrier, diffused junction	Low < 0.1%
	Beta & Electrons	All energies under 2 Mev with good resolution - surface barrier, diffused junction, lithium silicon	Low < 0.1%
	Gamma & X-rays	All energies - good resolution - with surface barrier and diffused junction.	Poor
		With Lithium drifted germanium or pure germanium.	Low

The discriminator prevents the counting of small impulses or electronic noise that is not due to the radioactivity being detected.

2.2.2.4 Pulse-Height Analyzers

The amount of light received from a scintillator or semi-conductor material is proportional to the energy deposited in the detector by the incident radiation. Likewise, the signal (pulse) from the photo-multiplier tube will be proportional to the energy. A pulse height analyzer sorts the pulses by their heights or the energy of the radiation.

Single channel analyzers count only those pulses within a single range. For example a single channel analyzer may be set to only accept pulses from radiation in the range of 1.14 to 1.20 MeV (Co-60). Thus only radiation from Co-60 would be counted. Multi-channel analyzers are a series of single channel analyzers.

2.3 General Instrument Characteristics

All radiation detection instruments have general characteristics of sensitivity, resolution, response time and efficiency that have to be considered in selecting the appropiate instrument.

2.3.1 Sensitivity

The sensitivity of an instrument is its ability to detect a particular type of radiation in a particular energy range. The construction of the instrument can affect the sensitivity regardless of the detector type being used. For example, window thickness is an important parameter in the construction of alpha and beta detectors. Table 3 gives ranges of energies that various detector types can detect.

The sensitivity of an instrument is also limited by the background count rate. For low level counting situations, such as test wipes, the error in the background count gives a lower limit to the amount of radiation that can be detected.

2.3.2 Resolution

The resolution of a radiation detector is the precision of the instrument in the measurement of the energy of the radiation (particles or rays).

2.3.3 Response Time

The response time of an instrument is the time delay until the instrument records 90% of an incremental change in the input signal. There are ratemeters which have a selection of response times. A longer response time would be used to smooth out the random rates at which the radiation is being detected.

2.3.4 Efficiency

The absolute efficiency of a radiation detector is the percentage of the source disintegrations that it will detect. That is,

$$\text{Absolute Efficiency} = \left(\frac{\text{count rate}}{\text{emission rate}}\right) \times 100\%$$

The absolute efficiency depends upon several factors:

(1) Geometry - The position of the detector relative to the source and the sizes of the detector and source affect the count rate. A large detector will intercept more radiation. In general the radiation intensity decreases with distance from the source. Leak test samples are small (filter papers or cotton swabs) and can be placed very close to the detector thereby maximizing the count rate.

(2) Radiation - The efficiency of a detector is a function of the radiation type and the energy of the radiation.

(3) Detector Construction - The efficiency of a detector is determined by the overall design characteristics. For example, a GM tube can detect alpha, beta and gamma rays beta and gamma rays, or only gamma rays depending upon the material used in the detector window.

In addition to absolute efficiency, the intrinsic and relative efficiences are commonly cited. The intrinsic efficiency of a detector is the percentage of particles striking the detector that are recorded. The relative efficiency of a detector is its efficiency relative to another detector or standard.

The efficiency of detectors is quoted in various ways. The following are examples:

(a) A GM detector may be quoted to have an efficiency of 30% for Sr-90 particles, 10% for C-14 beta particles and 5% for alpha particles greater than 3 MeV.

(b) A gamma detector may be quoted as giving a count rate per mR/hr for a particular radionuclide. For example, an efficiency could be 2500 cpm/mR/hr for Cs-137. This means that for 0.662 MeV gamma rays the detector will display 2500 counts per minute when placed in a field of 1 mR/hour.

There are a variety of methods used to determine the efficiency of detectors. Semi-conductor detectors for gamma spectroscopy [Ge(Li), Ge, Si etc.] employ a calibration source of mixed radionuclides to determine the efficiencies and energy calibrations over a wide spectrum of energies. Liquid scintillation counters employ either an internal standard method or an external standard method to determine the counting efficiency of prepared samples. The internal method is considered to be the more accurate because of the elimination of matrix effects and consists of a comparison between a sample count rate and a replica with an added known activity (spiked sample). The external method consists of the preparation of a set of vials with constant total volume of scintillant but a varying amount of sample. The count rate ratios and counting efficiencies are determined for the prepared vials. This technique has to be done for each radionuclide being analyzed.

3.0 Commercially Available Instruments

A major task for the project was the compilation of a list of commercially available detectors that are suitable for leak testing of sealed sources. Information was obtained from vendors by means of a mail survey described below.

3.1 Survey of Vendors

Information was solicited from 131 vendors across North America by a general mailing on October 6, 1986. A copy of the letter and the list of vendors canvassed are included in Appendix A.

The vendors were asked to submit technical specifications for instruments that will detect radiation at the level of 200 Bq with a 90% confidence level. A suitable instrument could be specific to a radiation type and energy range or a combination of radiation types and energies. Since some instruments being used by licensees may be no longer available, the vendors were also asked to provide the specifications for instruments being used but not being sold.

Information was obtained from 30 of 32 Canadian vendors. Nineteen of these companies were on the list of twenty suppliers provided by the AECB. Follow-up telephone calls were used to expedite responses from the Canadian vendors. This increased the responses by about 50 percent.

Twenty-five of ninety-nine vendors in the U.S. responded to the letter survey. Eleven vendors responded with information stating they did not manufacture or sell radiation detectors suitable for leak test analysis. Follow-up telephone calls were not made to expedite the responses from U.S. vendors.

The instrument list cannot be considered complete because of the low return from U.S. vendors. Notable examples are the following:

(a) No information was received on any suitable liquid scintillation detectors.

(b) No information was received from major vendors such as Beckman, Canberra, and EG & G Instrumentation.

In all cases the vendor's response was simply to forward catalogues and brochures on their product lines. The quality of information varied from fairly detailed specifications to the extreme of a product description with no technical specifications. It is presumed that they only sent information about detectors which they believed meet the specification of a 200 Bq detectability limit.

Only 5 of the vendors that responded to the survey market products that are specifically designed for leak testing. The commerically available leak testing instruments are summarized in Table 4.

The other 50 vendors, who responded with descriptions of instruments, do not offer designs that are specific to leak testing or contamination monitoring. A common practice is to assemble leak testing systems from the various components and instruments offered. Seven institutions that perform leak tests were surveyed and their practices are summarized in Appendix C. It illustrates the diversity of equipment being used for leak tests. The detectors and equipment that were judged to be candidates for a suitable leak testing system were identified from the information received. They are listed in Appendix B according to radiation type and detector type. A listing of ratemeters and scalers that can be used with a variety of detectors is included in Appendix B as well.

To be considered potential candidates for a leak testing system, detectors have to be able to detect low level radiation. For gamma rays the level is in the range of 0.01 uGy/hr. If an instrument can detect normal background radiation (0.1 uGy/hr) then it would likely be sensitive enough to detect 200 Bq of activity. For counting scales the level is in the lower portion of the 0-500 cpm range.

A system that is assembled for the purpose of leak testing would have to be commissioned and have its detection limits established. Since systems of this type are likely to be used by licensees, Appendix B was prepared from those detectors and components that appear to be suitable candidates for a leak testing system. The only detectors included are those where the vendor stated a sensitivity in the uR/hr or 0-500 cpm ranges.

The following general observations can be made regarding the types of detectors to be used for leak testing.

(a) Semi-conductor detectors and scintillators are suited for the detection of low level alpha, beta and gamma radiation. These types of detectors have a lower limit of energy that can be detected. Specially designed detectors have been developed to detect low energy gamma rays or x-rays. For example, different detectors are sensitive to energy ranges as follows:

Planar Ge Detectors:	2-200 keV
Low Energy Ge Detectors:	5-500 keV
Coaxial Ge Detectors:	50 keV - 10 MeV
Si(Li) Detectors:	$\leq$30 keV

Because of the sensitivity to energy a detector may be only useful for leak testing for specific radionuclides.

TABLE 4 COMMERCIAL LEAK TESTING SYSTEMS

VENDOR	MODEL	RADIATION	LOW RANGE
Bicron	Micro-Analyst UR Survey Meter	gamma	uR
	GI/GILE NaI (Tl)	gamma	2×10^{-5} mCi activity limit for I-125
Berthold	LB1200	beta/gamma	0.0-0.1 mR/hr
	LB1210 B/C/D/E	alpha/beta/gamma	0-20 Bq/cm^2
Cole-Parmer	Portable Contamination Monitor	gamma	0.002 uCi for I-125
Ludlum	3-98	gamma	Designed for I-125 0-500 cpm
Scintrex	AEP 5292A	beta/gamma	0-2000 cps

(b) Silicon surface barrier detectors are suitable for alpha and beta particle detection. Efficiencies for each detector should be known for the particle type and energy being detected.

(c) Gas proportional counters are suitable and are usually designed for low level alpha/beta counting. Detection efficiencies for any instrument have to be known. Beryllium gas proportional counter are available for x-ray detection.

(d) All Liquid Scintillation detectors with coincidence counting are suitable for beta detection. Efficiencies have to be determined by internal or external standards.

4.0 Radiation Characteristics of Sealed Sources

The selection of a leak test procedure for a particular sealed source requires knowledge of the type, energy and intensity of the radiation being emitted. This information was obtained (Ref. 7, 8) for the sources listed in Table 1 and it is summarized in Table 5. It is presented on the basis of detection of a 200 Bq source which is the limit of detectability set for the test procedures.

The following information is included for each of the sealed sources:

(1) The type and energy of the radiation emitted from the source radionuclide and its daughter(s). In the case of decay by orbital electron capture (EC) the energies of the excited states in the daughter nucleus are included in parentheses for each branch.

(2) The number of emissions of a particular radiation per 100 disintegrations of the parent source. In this column the daughter nuclide decays are normalized to the branching ratios of the parent disintegration.

(3) The total number of emissions of a particular radiation per minute given a parent (sealed source radionuclide) source activity of 200 Bq.

(4) For gamma emissions, the field strength at 1cm is estimated in uR/hour using the formula (Ref. 2):

$$S = 5600 \times C \times E$$

Where

C = Curies
E = energy in MeV
S = expected field in Roentgen/hr

This field strength is quoted in units of R/hr since many instrument specifications use this unit. In the SI system the corresponding unit is the Coulomb/kg. with 1R = 258 Microcoulomb/kg.

(5) The energies listed for beta particle emissions are the maximum beta energies for the decay.

In preparing Table 5 only significant decay branches were included for a particular type of emission. Generally, this meant omission of decay branches of a few percent. It is very unlikely that a detection procedure could be dependent on one of the omitted branches. Detailed emission spectra can be obtained from References 7 and 8.

TABLE 5 DECAY CHARACTERISTICS OF THE SEALED SOURCES (200 Bq)

ISOTOPE	ENERGY (MeV)	EMISSION/100 DISINTEGRATIONS	TOTAL EMISSIONS/ MINUTE	FIELD at 1Cm uR/Hr
C-14	Beta			
	0.156	100	12,000	
Fe-55	EC(0.0)	100		
	Bremsstralung			
	Q = 0.218			
	Mn Kx-ray			
	(0.0059-0.0065)	28		
Co-57	EC (0.136)	100		
	Gamma			
	0.0144	9	1,100	
	0.1220	86	10,300	~ 3.7
	0.1365	11	1,300	
Co-60	Beta			
	0.318	100	12,000	
	Gamma			
	1.173	100	12,000	~76.0
	1.332	100	12,000	
Ni-63	Beta			
	0.065	100	12,000	
Sr-90	Beta			
	0.546	100	12,000	
(Y-90)	2.284	100	12,000	
Ru-106	Beta			
	0.039	100	12,000	
(Rh-106)	Beta			
30 sec.	3.08	11	1,300	
	3.59	79	9,500	
	Gamma			
	0.512	21	2,500	~ 5.0
	0.622	10	1,200	

TABLE 5 DECAY CHARACTERISTICS OF THE SEALED SOURCES (200 Bq)

ISOTOPE	ENERGY (MeV)	EMISSION/100 DISINTEGRATIONS	TOTAL EMISSIONS/ MINUTE	FIELD at 1Cm uR/Hr
Cd-109	EC(0.088)	100		
	Gamma			
	0.088 (40s)	100	12,000	≃ 2.7
	Ag Kx-ray (0.0022-0.0026)			
I-125	EC(0.035)	100		
	Gamma			
	0.0355	7	800	≃ 0.07
	Te Kx-ray (0.027-0.032)			
Cs-137	Beta			
	0.512	95	11,400	
	1.176	5	600	
	Gamma			
	0.662	90	10,800	≃8.0
	Ba Kx-ray			
Ce-144	Beta			
	0.184	19	2,300	
	0.318	76	9,100	
	0.238	5	600	
	Gamma			
	0.080	2	200	
	0.134	11	1,300	≃ 0.5
(Pr-144) 17.3m	Beta			
	2.996	98	11,800	
Pm-147	Beta			
	0.225	100	12,000	

TABLE 5 DECAY CHARACTERISTICS OF THE SEALED SOURCES (200 Bq)

ISOTOPE	ENERGY (MeV)	EMISSION/100 DISINTEGRATIONS	TOTAL EMISSIONS/ MINUTE	FIELD at 1CM uR/HR
Gd-153	EC (0.0)	10		
	EC (0.097)	37		
	EC (0.103)	38		
	EC (0.173)	15		
	Gamma			
	0.0697	2	240	~ 1.8
	0.0974	29	3,500	
	0.1032	21	2,500	
	Eu Kx-ray			
Yb-169	EC (0.316)	4		
	EC (0.379)	82		
	EC (0.473)	14		
	Gamma			
	0.0631	42	5,000	~ 6.8
	0.0936	3	400	
	0.1098	17	2,000	
	0.1182	19	2,300	
	0.1305	12	1,400	
	0.1770	22	2,600	
	0.1980	36	4,300	
	0.3077	10	1,200	
	Tm Kx-ray			
Ta-182	Beta			
	0.258	30	3,600	
	0.437	20	2,400	
	0.522	40	4,800	
	Gamma			
	0.0677	41	4,900	
	0.1001	14	1,700	~28.4
	0.1524	7	800	
	0.2221	8	1,000	
	1.121	35	4,200	
	1.189	16	1,900	
	1.221	27	3,200	
	1.231	12	1,400	

TABLE 5 DECAY CHARACTERISTICS OF THE SEALED SOURCES (200 Bq)

ISOTOPE	ENERGY (MeV)	EMISSION/100 DISINTEGRATIONS	TOTAL EMISSIONS/ MINUTE	FIELD at 1Cm uR/Hr
Ir-192	EC(0.690)	5	600	
	Beta			
	0.256	6	700	
	0.536	41	4,900	
	0.672	48	5,800	
	Gamma			
	0.295	29	3,500	
	0.3084	30	3,600	~21.5
	0.3165	83	10,000	
	0.4680	48	5,800	
	0.6044	8	1,000	
Tl-204	EC(0.0)	3	400	
	Beta			
	0.763	97	11,600	
Pb-210	Beta			
	0.063	19	2,300	
	0.017	81	9,700	
(Bi-210)	Gamma			
	0.046	4	500	~ 0.05
	Beta			
	1.161	100	12,000	
(Po-210)	Alpha			
	5.304	100	12,000	
Ra-226	Alpha			
	4.601	6	700	
	4.784	94	11,300	
(Rn-222)	Gamma			
	0.186	4	600	~0.22
	Alpha			
	5.490	100	12,000	
(Po-218)	Alpha			
	6.002	100	12,000	

TABLE 5 DECAY CHARACTERISTICS OF THE SEALED SOURCES (200 Bq)

ISOTOPE	ENERGY (MeV)	EMISSION/100 DISINTEGRATIONS	TOTAL EMISSIONS/ MINUTE	FIELD at 1Cm uR/Hr
(Pb-214)	Beta			
	1.024	6	700	
	0.729	42	5,000	
	0.672	48	5,800	
(Bi-214)	Gamma			
	0.0532	12	1,400	
	0.2420	12	1,400	~ 8.79
	0.2952	30	3,600	
	0.3519	48	5,800	
	Beta			
	3.270	18	2,200	
	1.540	18	2,200	
	1.510	18	2,200	
	1.423	8	1,000	
(Po-214)	Gamma			
	0.609	46	5,500	
	1.120	15	1,800	~24.3
	1.238	6	700	
	1.764	16	1,900	
	Alpha			
	7.688	100	12,000	
Pu-238	Alpha			
	5.499	72	8,600	
	5.456	28	3,400	
	U Kx-ray (0.094-0.115)			
Am-241	Alpha			
	5.484	85	10,200	
	5.443	13	1,500	
	5.387	2	200	
	Gamma			
	0.0595	36	4,300	~ 0.65
	Np Lx-ray (0.012-0.022)			

TABLE 5 DECAY CHARACTERISTICS OF THE SEALED SOURCES (200 Bq)

ISOTOPE	ENERGY (MeV)	EMISSION/100 DISINTEGRATIONS	TOTAL EMISSIONS/ MINUTE	FIELD at 1Cm uR/Hr
Cm-244	Alpha			
	5.806	77	9,200	
	5.763	23	2,800	
	Pu Lx-ray (0.012-0.023)			

4.1 Leak Test Kit

CSLD inspectors require a set of standard sources to be used in checking the leak testing instruments and procedures of licensees. It should contain radionuclides having sufficiently diverse radiation characteristics that it provides a sensible check of procedures being used to detect leaks from any of the possible sources listed in Table 1.

Handling and availability of sources imposed the following constraints on the selection of test kit contents:

(1) the radionuclides are to be available from the AECB laboratory.

(2) the number of test sources should be small so that the kit is easily portable.

(3) only solid sources are included for safety in handling.

The radionuclide contents of a proposed test kit are given in Table 6. The nuclides were selected with the following criteria:

(i) all radiation types are represented

(ii) the range of energy for each radiation type is represented

(iii) the radionuclides have relatively long half-lives so that new test sources would not have to be made more frequently than once per year.

The licensee's leak test instruments are to be sensitive enough to detect 200 Bq of activity from a specific radionuclide on a test wipe. The initial source activity required for a minimum of 200 Bq after one year is given in Table 6.

The proposed test kit includes Co-60 and Cs-137 as gamma ray sources of high and medium energy. The photon yield from the Co-60 source is two photons per disintegration and from Cs-137 the yield is 0.90 photons per disintegration. Low energy gamma rays are emitted by the Am-241 source with a yield of about 0.36 photons per disintegration.

The Ni-63 and Sr-90 sources give beta emissions of low and high energy that are free of gamma rays from daughter decays. However, the Sr-90 daughter, Y-90, also beta decays with an energy of 2.28 MeV and 64 hour half-life so that the source will also contain 200 Bq of Y-90 after 27 days. The beta emissions

from the Co-60 and Cs-137 sources are of intermediate energies.

The Am-241 source gives alpha particles in the middle of the range (4.8-5.8 MeV) for the alpha emitting radionuclides from Table 1.

A blank planchet is recommended for inclusion in the test kit to serve as a control and monitor for background activity. If the blank source is handled as the others when using the test procedure it will serve as a control for checking contamination of the test kit.

The proposed test kit does not include sources for testing liquid scintillation counters. Liquid Ni-63 or C-14 sources could be prepared and maintained as separate sources to be used if the need arises.

The test kit would be prepared on aluminum or stainless steel planchets to ensure conformity and durability of the sources. Source identities, activity and date of origin would be engraved on the planchets. There are many ways the test kit could be packaged. A simple method would be to fix the planchets in tightly covered petri dishes.

When the test kit is prepared, the source strength will have to be corrected for any scattering effects in the sample medium. This would include corrections for back scattering from the sample backing and absorption in the sample covering. The final product should have a source strength equivalent to the 200 Bq limit of detectability.

TABLE 6 RADIONUCLIDE SOURCES FOR A TEST KIT

Isotope	Minimum Initial Activity (Bq)	Energy (MeV)	Emissions $(100\ Bq)^{-1}$	Total Emissions $(min)^{-1}$	Field uR at 1 cm	Comments
Co-60	230	Beta				
		0.318	100	13,800		
		Gamma				
		1.173	100	13,800	87 uR	Higher than average energy
		1.332	100	13,800		
Ni-63	200	Beta				
		0.066	100	12,000	---	Low
Sr-90	205	Beta				
		0.546	100	12,300	---	Higher than average energy
(Y-90)		(2.284)				
Cs-137	210	Beta				
		0.512	95	12,000		
		1.176	5	600		
		Gamma				
		0.662	90	11,300	19 uR	Average energy
Am-241	200	Alpha				
		5.389	1	100		Average alpha energies
		5.443	13	1,600		
		5.486	85	10,200		
		Gamma				
		0.0595	36	4,300	0.6 uR	
Blank Planchet				Background		

5.0 Procedures for Leak Testing

A licensee's leak test procedures will be specific to particular radionuclides, the detection method, and the instruments being used. Nevertheless, all procedures will reflect certain elements of good practice that ensure confidence in the test results. The following items are discussed below:

(1) test objective

(2) equipment selection

(3) test procedures

(4) staff training

(5) quality assurance

5.1 Test Objective

The objective of a leak test procedure is to determine with a high level of confidence if a leak exists. The measurement of the amount of activity on a test wipe is not of great importance initially. Further analysis would be required to quantify the leakage once a source has been identified as leaking.

Nearly all test results will show no detectable leakage. Thus, the procedure must include steps that give confidence that a contaminated test wipe would have been detected. Testing a check source along with the test wipes is one way of providing the necessary confidence. In general, the level of confidence in the test procedure is a function of the frequency of application.

The specified limit of detectability for a test procedure is 200 Bq of the source radionuclide on a test wipe. In most cases, the test procedures will be capable of detecting less than 200 Bq. The existence of any activity above background levels shows that the source is leaking. The test procedures should address any positive result and not just a threshold of 200 Bq.

5.2 Selection of Equipment

In a few cases the radionuclide to be detected emits a single type of radiation such as the beta emitters C-14 and Ni-63. However, in most cases there are de-excitation gamma rays from the daughter nuclide so that there is a choice of methods for detecting a particular radionuclide. In all cases, the equipment must be capable of detecting 200 Bq of the source nuclide. In cases where there is a choice of detection methods it is preferable to use the more sensitive method and/or more reliable procedure. For example, a procedure for gamma

detection can usually be applied with a higher level of confidence than an alpha detection procedure.

The information in Table 5 can be used to determine the suitability of a particular detection system. It gives the emission rate for each type of radiation being emitted from a 200 Bq source. Knowing the efficiency of a detector, the expected count rate can be readily obtained.

In general, laboratory and monitoring equipment that is normally used for other purposes will be used for leak testing. This means that the licensee will have to verify that this particular system is in fact capable of detecting 200 Bq of a specific radionuclide on a test wipe. A 200 Bq check source of the radionuclide should be used to commission the leak detection system.

5.3 Test Procedures

Having selected and commissioned leak test equipment, procedures have to be developed for routine leak testing. These procedures must be sufficiently detailed to ensure meaningful and reproducible test results. Among other things, the procedures will include consideration of the following:

(1) Background count rate

(2) Counting times

(3) Detector efficiency

(4) Limit of detectability

(5) Detector/source geometry

The background count rate must be known for each test and should be measured under the same conditions. This can be done by using a blank source and following the leak test procedure. The background count rate should be kept as low as possible to enhance the accuracy of the test.

The test procedure must specify counting times that will yield the desired level of detectability with 95% confidence. Handbooks, such as Reference 2, include graphs for determining counting errors and the error in the difference between the source and background count rates.

The intrinsic efficiency of the detection system must be known to infer the source strength from the measured count rate. It

is sufficient for leak test purposes to use a conservative value of the efficiency. Thus, the test procedure should include a routine verification of a conservative value for the detection efficiency. For example if the detection efficiency is known to increase with energy, it is sufficient to determine an efficiency at low energy and use that value at all energies.

The fraction of the total source strength that is intercepted by the detector must be known to infer the source strength. The test procedure must specify a fixed counting geometry that will be used in all tests.

The 200 Bq limit of detectability must be converted to an action limit for defining a source leak in each particular test. It would be prudent to choose the action limit as low as is achievable rather than use 200 Bq.

5.4 Staff Training

The licensee's staff, who are responsible for leak testing, must be trained in using the test procedures so that results are reproducible and meaningful. They should be familiar with the capabilities and limits of the detection equipment as well as the radiation characteristics of the particular sources being tested.

5.5 Quality Assurance

A leak test program should include the following elements so that the quality of the test results is assured.

(1) Verification that the test procedure can achieve the required limit of detectability.

(2) The test procedure should be documented in a format that can be followed without error to give reproducible results.

(3) Routine verification that the detection equipment is functioning properly.

(4) A record system for all equipment tests and a log of leak tests performed.

6.0 Summary

One hundred and thirty-one vendors of radiation detection equipment were surveyed to identify commercially available instrumentation for leak testing. Five systems were identified as being marketed for leak testing. Vendors sell numerous other general purpose detectors and components that can be assembled into leak detection systems. This equipment is summarized in Tables in Appendix B by detector type and radiation type. Detection systems that are assembled from components should be commissioned with check sources to verify the 200 Bq limit of detectability.

The radiation characteristics of the sealed sources that are licensed by the AECB are summarized in Table 5. All of the principal emissions are listed with energies and the number of emissions per minute from a 200 Bq source. This Table can be used to select a leak test method for a particular radionuclide.

A leak test kit, that would be used to verify licensee's test procedures, was developed (Table 6). It contains five sources covering the radiation types and energies of all the licensed sources.

Leak test procedures will be specific to each detection system and radionuclide. Nevertheless, there are general principles that should be included in each specific procedure. It is particularly important that the procedures be well documented and controlled with only trained staff performing the leak tests.

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APPENDIX A

VENDOR SURVEY

A.1 Survey Description

The survey was undertaken to identify the commercially available radiation detection instruments for leak testing of sealed sources. A list of vendor's was prepared from the following sources:

(1) A list of 18 Canadian vendors provided by the AECB.

(2) The Buyer's Guides from Physics Today and from Nuclear News.

(3) Reader Service Cards from Nuclear News, Physics Today and Health Physics.

A total of 131 vendors listed below were canvassed with the following letter.

A2

ATLANTIC NUCLEAR SERVICES LTD. (506) 458-9552

390 KING ST., BOX 1268, STN. A., FREDERICTON, N.B. E3B 5C8

October 6, 1986

Dear Sir/Madam.

Atlantic Nuclear Services is a consulting engineering company which speacializes in nuclear, regulatory and environmental consulting.

The Company has been commissioned by the Atomic Energy Control Board of Canada (AECB), to compile a list of all commercially available Radiation Detectors acceptable for use by licensees to do leak tests of sealed radiation sources. AECB inspectors will have this list when doing their on-site inspections of Licensee's facilities.

The main requirement of a suitable instrument is it's ability to detect levels of radiation equal to or greater than 200 Becquerels (200 disintegration /second or 5.4 x E-9 Curies) with a 90% confidence level. A suitable instrument can be specific to any radiation type (alpha,beta,gamma), or combination of radiation types and energy.

In order that your instrument may be included in the list, please forward to us the following information:

1) Technical specification for instruments that are being marketed now;

2) Technical specifications for instruments that are no longer being sold, but your customers are still using.

I thank you in advance for your cooperation. If you have any queries or additional information to provide please feel free to contact me.

Sincerely,

Norm Arbeau
Project Scientist

Levett Safety Ltd.
33 Laird Drive
Toronto, ON M4G 3S9

Atomic Energy of Canada Ltd.
P.O. Box 13500
Kanata, ON K2K 1X8

Mr. Walt Klywak
Ramsey REC Ltd.
385 Enford Road
Richmond Hill, ON L4C 3G2

Mr. D. Cooper
ADG Atomic Testing Instruments Ltd.
P.O. Box 772 Station F
Calgary, Alberta T2H 2H3

Mr. D. Russell
Russell Ultra-Sound Services Ltd.
4909 75 Avenue
Edmonton, AB T6B 2S3

Mr. D. Patterson
Quality NDE Ltd.
484 St. Jean Baptiste Est.
Mercier, P.Q. J0L 1K0

Pylon Electric Development Co. Ltd.
147 Colonnade Road
Nepean, ON

Trimet Instruments Ltd.
1792 St. Mathews Ave.
Winnipeg, Manitoba
R3H 0A5

Nu Rad Instrumentation Ltd.
8 Essex Ave., Unit 14
Thornhill, ON
L3T 3Y9

Aptec Nuclear Inc.
210 8th Street
Lewiston, NY 14092

Barnes Engineering Co.
44 Commerce Rd.
P.O. Box 53
Stanford, CT 06904

Mr. Murray Fitz-Henry
GEC Canada Ltd./Eastern Electric Div.
5112 Timberloa Blvd.
Mississauga, ON L4W 2A5

Dr. George A. Borun
HI-Q Environment Prod. Co.
P.O. Box 2847
La Jolla CA 92038

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Ionex Research Corp.
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1100 Invicta Dr. Unit 8
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2460 N. Arlington
Indianapolis IN 46218

Mr. Brian Munro
Non-Destructive Testing Products Ltd.
P.O. Box 963
Oakville, ON L6J 5E8

Mr. David Katzman
Panasonic Industrial Co.
One Panasonic Way
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Mr. R.F. Stopelli
R-Metrics Ltd.
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Mr. Minuk
Rayonics Scientific Inc.
585 Canarctic Dr.
Downsview, ON M3J 2P9

Mr. Murray Fitz-Henry
Reactor Experiments Inc.
963 Terminal Way
San Carlos CA 94070-3278

Rondequoit Industries
440 Hoffman Rd.
Rochester, NY 14622

Judson Infared Inc.
21 Commerce Dr.
Montgomery, PA 18936

Micron Semiconductors Inc.
126 Baywood Ave.
Longwood, FL 32750

Radiation Monitoring Devices Inc.
44 Hunt St.
Watertown, MA 02172

Spex Industries Inc.
3880 Park Ave.
Edison, NJ 08820

United Detector Technology
12525 Chadron Ave.
Hawthorne, CA 90250

Amperex Electronic Corp.
Hicksville Div.
230 Duffy Ave.
Hickville, NJ 11802

Instrument Technology Ltd.
10747-3 Tucker St.
Beltsville, MD 20705

International Light Inc.
Dexter Industrial Green
Newburyport, MA 01950-4092

ITT Electro-Opt. Products Div.
(Tube and Sensor Labs)
3700 E. Pontiac St.
P.O. Box 3700
Fort Wayne, IN 46801

National Diagnostic
1013-1017 Kennedy Blvd.
Manville, NJ 08835

Scientific Services Co.
P.O. Box 317
5 Crescent Ave.
Rocky Hill, NJ 08553

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Scintrex Ltd.
222 Snidercroft Rd.
Concord ON L4K 1B5

Mr. C.E. Winters Jr.
Suntrac Services Inc.
P.O. Box 57722
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Telodyne Analytical Instruments
16830 Chestnut Street
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85 Ferrier St. Unit 5
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6620 Kitimat Rd., Ste. 6
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Opto Electronics Inc.
Unit 9 2538 Speers Rd.
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L6L 5K9

Acrolab
Box 2425
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Optikan Corp. Ltd.
410 Conestogo Rd.
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Toronto, ON M4H 1H1

UV Process Supply Inc.
4001 N. Ravenswood Ave.
Chicago IL 60613

Phillips Scientific
13 Ackerman Ave.
Suffern, N.Y. 10901

EL-Tech Technology Inc.
7 Woodland Ave.
Larchmont, NY 10538

Products for Research Inc.
88 Holten St.
Danvers, MA 01923

Johnston Laboratories
383 Hillen Road
Towson, MD 21204

Liconix
1390 Borregas Ave.
Sunnyvale, CA 94089

Markson Science
Div. of AXIA Inc.
78155
46th St.
Phoenix, AZ 85040

Mr. David J. Allard
TGM Detectors Inc.
160 Bear Hill Rd.
Waltham, MA 02154

Victoreen Inc.
10101 Woodland Ave.
Cleveland, OH 441044

ADIT Co.
1525 Kings Hwy. E.
P.O. Box 743
Fairfield, CT 06430

Advanced Research and Applications
1223 E. Arques Ave.
Sunnyvale, CA 94086

BEA Electro-Optics Corp.
690 First Ave.
Des Plaines, IL 60016

Boston Electronics Corp.
72 Kent St.
Brookline, MA 0216

Centronic Electro-Optics Inc.
1101 Bristol Rd.
Mountainside, N.J. 07092

EG and G Gamma Scientific
3777 Ruffin Rd.
San Diego, CA 92123

EG and G Vactec
10900 Page Blvd.
St. Louis, MO 63132

EMR Photoelectric and Nuclear
Div. of Schlumberger Ltd.
P.O. Box 44
20 Wallace Rd.
Princeton, NJ 08542

Hamamatsu Corp.
360 Foothill Rd.
P.O. Box 6910
Bridgewater, NJ 08807

Integrated Photomatrix
c/o Centronic Inc.
1101 Bristol Rd.
Mountainside, NJ 07092

Micron Corp.
12345 Kingsman Road
Newbury, OH 44065

Dexter Research Center Inc.
7300 Huron River Road Drive
Dexter, MI 48130

Dosimeter Corp.
11286 Grooms Rd.
Cincinnati, OH 45242

EG and G Ortec
100 Midland Rd.
Oak Ridge, TN 37831-0895

Ford Aerospace and Comm
Aeronautic Division
Ford Road
Newport Beach, CA 92660

Mr. Robert W. Lehnert
LND Ind.
3230 Lawson Blvd.
Oceanside, NY 11572

New England Photoconductor
7 Lawrence St.
Taunton, MA 02780

Nuclear Enterprise America
23 Madison Rd.
Fairfield, N.J. 07006

Research Products Intl. Corp.
410 N. Business Center Drive
Mt. Prospect, IL 60056

Rexon Components Inc.
5622 Grand PI.
Willoughby, OH 44094

Surface Science Labs Inc.
Analytical Instruments Division
465 National Avenue
Mountain View, CA 94043

Tech Ops. Inc.
Radiation Products Division
40 North Avenue
Burlington, MA 01803

Pfaltz and Bauer Inc.
172 E. Aurora St.
Waterbury, CT 06708

Scientific International Inc.
P.O. Box 143
Princeton, N.J. 08542

Optovac
An Em Industries Co.
East Brookfield Rd.
North Brookfield, MA 01535

Anoroc Scientific
P.O. Box 2001
South Hackensack, N.J. 07606

Bakish Materials Corp.
P.O. Box 148
Englewood, N.J. 07631

Isotopes Products Laboratories
1800 N. Keystone St.
Burbank, CA 91504

Polycast Technologyy Corp.
P.O. Box 141
Stamford, CT 06902

Canberra
One State St.
Meriden, CT 06450

Amperex Electronic Corp.
Hicksville Div.
230 Duffy Ave.
Hicksville, N.Y. 11802

E.G.G. (PARC) Princeton Applied Research
P.O. Box 2565
Princeton, N.J. 08543-2565

Griot Ass. Inc.
216A Main St.
Los Altos, CA 94022-2966

LeCroy Corp
700 S. Main Street
Spring Valley, N.Y. 10977

Wm. B. Johnson and Associates Inc.
P.O. Box 98
Research Park
Montville, N.J. 07045

Baird Corp.
125 Middlesex Tpke.
Bedford, MA 01730-1468

Keithley Instruments Inc.
28775 Aurora Rd.
Cleveland, OH 44139

Ludlum Measurements Inc.
501 Oak St.
P.O. Box 810
Sweetwater, TX 79556

Research Products Int'l
410 Business Center Dr.
Mt. Prospect, IL 60056

Safety Specialists Inc.
P.O. Box 4420
3060 Raymond St.
Santa Clara, CA 95054

RADCAL Corporation
426 West Quarte Road
Monrovia, CA 91016

Tennelec
601 Oak Ridge Turnpike
P.O. Box 2560
Oak Ridge, Tennesee 37831-2560

Beckman Industrial Corp.
Cedar Grove Div.
89 Commerce Rd.
Cedar Grove, N.J. 07009

Blake Industries
660 Jerusalem Rd.
South Plains, N.J. 07076-2099

National Diagnosters
1013-1017 Kennedy Blvd.
Manville, NJ 08835

Atomergic Chemetals Corp.
91 Carolyn Blvd.
Farmingdale, N.Y.

Thermometrics Inc.
808 US Hwy. No. 1
Edison, N.J. 08817

Atomic Products Corp.
P.O. Box R
Shirley, N.Y. 11967

Berthold Analytical Instruments
28 Charron Ave.
Nashua, N.H. 03063

Eberline Analytical Corp.
P.O. Box 3874
Albuquerque, NM 87190

Harshaw/Filtrol Partnership
6801 Cochran Rd.
Solon, OH 44139

Nuclear Equip. Chemical
280 Smith Street
Farmingdale, N.Y. 11735

Nuclear Sources and Services Inc.
Box 34042
Houston, TX 77234

Syncor International Corp.
12847 Arroyo St.
Sylmar, CA 91342

Technical Associate
7051 Eton Ave.
Canoga Park, CA 91303

Tech Ops. Inc.
Radiation Prods. Division
40 North Ave.
Burlington, MA 01803

Whatman Lab Sales Inc.
5285 NE Elam Young Pkwy.
Suite A-400
Hillsboro OR 97124

Minuteman Laboratories Inc.
916 Main St.
Acton, MA 01720

Capintec Inc.
6 Arrow Road
Ramsey, N.J. 07446

Concept Engineering
47 Ragged Rock Rd.
Old Saybrook, CT 06475

Eltec Instruments Inc.
P.O. Box 9610
Daytona Beach, FL 32014

Laser Precision Corp.
1231 Hart St.
Utica, N.Y. 13502

Leeds and Northrup Instruments
Unit of General Signal
Sumney town Pike
North Wales, PA 19454

Pulse Systems Inc. (PSI)
422 Connie Ave.
Los Alamos, NM 87544

Spiricon Inc.
2600 N Main
Logan, UT 84321

Concept Engineering
43 Ragged Rock Rd.
Old Saybrock, CT 06475

Dexter Research Center Inc.
7300 Huron River Drive
Dexter, MI 48130

Eppley Laboratory Inc.
12 Sheffield Ave.
Newport, R.I. 62840

General Microwave
5500 New Horizons Blvd.
Amityville, N.Y. 11701

Phillips Scentific
13 Makerman Avenue
Suffern, N.Y. 10901

Products for Research Inc.
88 Holtin Street
Denvers, MA 01923

Mr. Bob Gable
Aptec Engineering Ltd.
4251 Steeles Avenue
W. Downsview, Ontario N3N 107

Mr. C. Babrock
Barringer Research Ltd.
304 Carlingview Drive
Rexdale, Ontario M9W 5G2

Canadian Astronautics Ltd.
1050 Morrison Drive
Ottawa, Ontario K1S 2L4

Mr. Brian Flippance
Allan Crawford Associate
5835 Coopers Avenue
Mississauga, Ontario L7U 1Y0

BAM Electrotech
77 Rang St-Joseph
St.-Marc sur Richelieu J0L 2E2
(Phoned only)

APPENDIX B

COMMERCIALLY AVAILABLE RADIATION DETECTION INSTRUMENTS

B.1 Summary of Information from the Vendor Survey

The product information provided by vendors was reviewed to identify detectors, counters and radiation detection instruments that would likely be suitable for use in a leak detection system. The selected products are asssembled in Tables by radiation type and detector type for easy reference as follows:

TABLE B-1 ALPHA DETECTORS

TABLE B-2 ALPHA/BETA DETECTORS

TABLE B-3 BETA DETECTORS

TABLE B-4 BETA/GAMMA DETECTORS

TABLE B-5 GAMMA DETECTORS

TABLE B-6 GAS PROPORTIONAL DETECTORS

TABLE B-7 GEIGER-MUELLER DETECTORS

TABLE B-8 SCINTILLATION DETECTORS

TABLE B-9 SEMI-CONDUCTOR DETECTORS

TABLE B-10 COUNTING ELECTRONICS (SCALERS/RATEMETERS)

The following qualifications should be considered when making use of the Tables.

(1) The survey of vendors was not exhaustive since only 66 responses were received from the 131 vendors canvassed.

(2) Instruments that are being used but no longer being sold are not included.

(3) Limited product information was obtained so that there may be errors and ommissions in the lists.

(4) A particular detector or component does not make an acceptable leak testing system. The system that is assembled must be commissioned and verified to provide the required level of detectability.

TABLE B-1 ALPHA DETECTORS

VENDOR	MODEL/TYPE	COMMENTS
Aptec	EW10	GM tube only - alpha/beta/gamma
	BM-1	GM tube only, stated to be good for low statistical error counting
	PHYGE Charged Particle Detector	Alpha/beta/proton spectroscopy
Bicron	A50 Alpha Scintillator (ZnS)	
	AB1 Scintillator (ZnS)	
	B50 Alpha/Beta Scintillator	
	B1 Scintillator	
	TPGM/APGM/PGM GM Detectors: alpha)3 MeV beta)45 keV gamma)8 keV	Compatible with PGM Bicron Swegar /50/200/2000
Eberline	AC-3 Alpha Scintillation Probe	Detector only
	AC-21 Gas Flow Proportional Probe	Detector only
	SAE4 ZnS(Ag) Scintillation Alpha Counter	
Johnson and Associates	ASP - 2 Scintillator	
Levitt Safety	Monitor 4	Alpha, beta, gamma 0-500 cpm

TABLE B-1 ALPHA DETECTORS (Con't)

VENDOR	MODEL/TYPE	COMMENTS
Ludlum	61 Air Proportional Alpha Counter	16% Efficiency
	43-1/2/5/9/10 Alpha Scintillation Detector	ZnS(Ag)
	43-4/20/44/45/46 Air Proportional Alpha Detector	
	43-17 Si Alpha Detector	
	120 Gas Proportional Detector (Alpha/Beta)	
Pylon	PMTSA ZnS(Ag)	20% efficient for alpha
	PMTSAB (Alpha/Beta)	20%/13% efficient for alpha/beta
Technical Associates	Stam 2 Scintillation Probe	

TABLE B-2 ALPHA/BETA DETECTORS

VENDOR	MODEL/TYPE	COMMENTS
Baird	Accucount/Centicount Low Background Alpha/Beta/Gamma Planchet Counting System	
Berthold	LB 1210 C/E	Automatically incorporates calibration factors
	10-Channel Low Level Planchet Counting System LB-770	
EG and G	Ortec Silicon Surface Barrier Detectors for Particle Detection - Series A, B, E	
Nuclear Measurements Corporation	PC-5/55 Proportional Counters	
	ACS-82/84 Proportional Counter	
Tennelec	LB 5100 Series III/II	Low background, gas proportional alpha/beta/gamma system
	LB 5100-PW Alpha/Beta/Gamma Counting System (NaI)	Planchet samples
	5500 Low Background Alpha/Beta Gas Proportional System	Planchet samples
	LB 1000 Series Manual Low Background L/B Gas counting	Planchet samples
Trimet	TM-372A	Filter paper or planchet sample

TABLE B-3 BETA DETECTORS

VENDOR	MODEL/TYPE	COMMENTS
Aptec	PHYGE Charged Particle Detector	Alpha, beta, proton spectrometry
Beckmen	LB 8000/5801 Liquid Scintillator Counters	
Eberline	BC-Y Beta Counter	GM tube, removable window for low level betas (i.e. C-14)
	HP-190A Hand Detector	GM tube
	HP-210 Pancake Detector	Sensitive to alphas >3 MeV
	HP-260 Pancake	Sensitive to alphas >3 MeV
Ludlum	44-1 Scintillator	C-14 detectors with alpha rejection
Pylon	PMT-SB Surface Contamination Probe	14% efficient for beta
	PMT-SAB Surface Contamination Paper	20%/13% efficient for alpha/beta
Victoreen	943 Plastic Scintillation Detector	

TABLE B-4 BETA/GAMMA DETECTORS

VENDOR	MODEL/TYPE	COMMENTS
Aptec	FT-252/366 GM Tube	
	FT -56 GM Tube	
	BH-5C6 GM Tube	
	BH-8C6 GM Tube	
	EWIV	GM tube (alpha/beta/gamma)
	BM-1	GM tube (alpha/beta/gamma), stated to be good for low statistical error counting
	KBAS GM Tube	Designed for uranium evaluation
	EK-1	Sensitive to low activity
Berthold	LB 1210 B/D	Automatically incorporates calibration factors
	LB 1200 GM Tube	Sensitive to background fields (10 uR/h). Good for I-125
	Rato/F (Similiar to LB 1200)	Low detection limit is 10 uR/hr
	LB-133/TOL/E	Sensitive to 10 uR/hr fields Used commonly as a dose rate meter
Bicron	TPGM/APGM/PGM/EWGM/SWGM GM Detectors for Contamination	Compatible with Bicron count rate meters
Eberline	AC-21B Gas Flow Proportional Probe	
Johnson and Associates	GP-90/200 GM Detector	
Levitt Safety	GM Monitor 4 (Alpha/Beta/Gamma)	0-500 cpm
Ludlum	3-98 External Scintillaor for Iodine (Internal GM Detector)	0-500 cpm low scale
Scintrex	AEP 5297A GM Contamination Monitor	1-1999 cps

TABLE B-5 GAMMA DETECTORS

VENDOR	MODEL/TYPE	COMMENTS
Aptec	GH Series	GM tube only
	PHYGE Coaxial Spectrometer (Ge) CS Series	Gamma and high energy X-rays
	PHYGE Planar Spectrometer (Ge) PS Series	X-rays and low energy gamma rays
	HPGE ED Series (Ge)	Low background detectors
Berthold	LB 742/1026 NaI Detector	Well detector
Bicron	Micro Rem Survey Meter Labserco	Organic scintillator, 0-20 uRem/hr
	G1/G1LE NaI(TL) Detector	High sensitivity: I-125 $\geq$ 2 x 10^{-5} mCi/Cm^2 limit for G1LE
	G2/3/5 NaI	Scintillator, gamma sensitive
	G2 LE NaI	>90% efficient for I-125
	Micro-Analyst uR Survey Meter	
	Swegor 50	
Cole-Parmer	Portable Contamination Monitor	0.002 uCi I-125 detectable
Eberline	LEG-1 Low Energy Gamma Probe (Scintillation NaI)	Designed for I-125 Needs a ratemeter or scaler
	PG-2 Low Energy Gamma and X-Ray Detector NaI(TL)	Needs a ratemeter or scaler
	SAM-2 Stabalized Assay Meter with an RD NaI(TL) detector	
	SPA-3 NaI(TL) High Sensitivity Detector	
	SPA-6 NaI(TL) Medium Sensitivity Detector	

TABLE B-5 GAMMA DETECTORS (Con't)

VENDOR	MODEL/TYPE	COMMENTS
Johnson and Associates	GSP-2A (NaI)	0.0005 uCi sensitivity
	DGSP-2A (NaI)	I-125 sensitive
	GLE NaI	Low energy gamma
Keithley	36000 Series	Meters sensitive to uR fields
Ludlum	14C Alpha/Beta/Gamma	Low scale is 0.0-0.2 mR
	5 gamma	Low scale is 0.0-0.2 mR
	19 Low Level Scintillator	0-25 uR/hr low scale
	44-2 Background Gamma Scintillator (NaI)	
	44-3 NaI	Designed for I-125 and X-rays
	44-10 NaI	Low level gamma detection
	44-11 NaI	Low level gamma assay
	44-12/14/17/21/22/23/33 NaI	
	203/243 Gamma Assay (NaI)	Shielded well counter
PGT	Variety of Ge, Ge(Li) and Si Detectors	
Pylon	PM7-GB High Sensitivity Beta and Gamma Probe (NaI)	5% efficiency, 100 cpm/uR/hr
	Low energy Gamma and X-Ray Probe NaI	28% efficiency, 10 cpm/uR/hr
Scintrex	BGS-3/4 Gamma Scintillation Counters (NaI)	Designed for U prospecting Sensitive enough for contamination, 0-20,000 cps
Technical Associates	STG-4/41/41P NaI Systems	
	STB-3 B/B System	

TABLE B-5 GAMMA DETECTORS (Con't)

VENDOR	MODEL/TYPE	COMMENTS
Victoreen	I-125 "Seed Finder" Survey Meter	0-500 CPM Low range
	897 Series GM Detector TGM N117	10uR-1000 mR
	943 Series NaI	

TABLE B-6 GAS PROPORTIONAL DETECTORS

VENDOR	MODEL/TYPE	COMMENTS
Berthold	LB 1210 B/C/D/E	For alpha/beta or beta/gamma contamination detectors
	LB770 10-Channel Low Level Alpha/ Beta Planchet Counting System	
Eberline	Probe AC-21 Gas Flow Proportional	Alpha detector
	Probe AC-21B Gas Flow Proportional	Beta detector
Ludluam	61 Air Proportional Detector	Alpha detector, 6% efficiency
	43-4/20/44/45/46 Air Proportional Detector	Alpha detector
	720 Alpha/Beta Detector	
LND	Proportional Detectors	Limited technical data on sensitivity levels
Nuclear Measurements Corporation	PC 5/55	Alpha/beta detection, efficiency vary for different isotopes.
	ACS-82/84 PIOPS	Alpha/Beta detector
Tennelec	LB5100 Series II/III Gas Proportional Alpha/Beta/Gamma Low Background Detection System	
	LB5500 Low Background Alpha/Beta	
	LB1000 Low Background Alpha/Beta	

TABLE B-7 GEIGER MUELLER DETECTORS

VENDOR	MODEL/TYPE	COMMENTS
Aptec	FT-252/366 Beta/Gamma	Gas tube only
	FT-56 Beta/Gamma	Gas tube only
	RH-5C6 Beta/Gamma	Gas tube only, 60 cpm (background)
	RH-8C6 Beta/Gamma	Gas tube only, 90 cpm (background)
	GH Series Gamma Detectors	Gas tube only
	BM-1 Alpha/Beta/Gamma	Gas tube only, stated to be good for low level activity detection.
	12BAS	Gas tube only, designed for Uranium Ore
	EK1	Would be sensitive enough for contamination analysis.
Berthold	LB-133	Designed as a doserate meter
	TOL/E	Has sufficient sensitivity for background fields
Bicron	EWGM	Designed for contamination probes only, alpha >3 MeV, beta >45 keV, gamma >6 keV
	SWGM	Beta >200 keV, gamma >12 keV
	TPGM/APGM/PGM	Alpha/beta/gamma contamination detector
Cole-Parmer	Portable Contamination Monitor	0.002 uCi I-125 detection limit

TABLE B-7 GEIGER MUELLER DETECTORS (Con't)

VENDOR	MODEL/TYPE	COMMENTS
Eberline	Model BC-Y Beta Counter	15% efficient for C-14 beta.
	Model HP-190A Beta Detector	10% efficient for C-14 beta.
	Model HP-210 Beta Detector	Alpha >3 MeV
	Model HP-260 Hand Probe	Beta-alpha >3 MeV
	Model HP-270 Hand Probe	Background to 3000 mR/hr
Johnson and Associates	GP90/200 Beta/Gamma	
	GPPA2 /HP-265	Pancake beta/gamma
Keithley	3600 Series Survey Meters	Sensitive to uR fields
LND	Pancake Detectors 7311/8767	Most commonly used - limited information, on sensitivity levels
Ludlum	3-98 External Scintillator for Iodine	Internal GM (beta/gamma). 0-500 cpm low scale
	14C	Sensitivity dependent on detector type and scale in use.
Scintrex	AEP 52921A Beta/Gamma Contamination Monitor	1-2000 counts/sec
Technical Associates	STB-3 Pancake Detector	
Tennelec	GM Detectors	Limited technical information. Sensitivity depends on system design.
TGM/Centronic	Pancake Detectors	Dependent on electron energies and window density.
Victoreen	I-125 "Seed Finder" Survey Meter	0-500 cpm low range
	Model 897 Series TGM N117	10 uR - 1000 mR/hr

TABLE B-8 SCINTILLATION DETECTORS

VENDOR	MODEL/TYPE	COMMENTS
Berthold	LB742/1026	NaI well detector
Bicron	Organic Micro Rem Survey Meter	0-20 uRem/hr low range
	G1 Scintillation Probe (NaI)	Gamma detector
	G1LE NaI	)90% efficient for I-125 gammas, (10-60 keV)
	A50 Alpha Detector (ZnS)	
	B50 Alpha/Beta Detector	
	G2/3/5 (NaI)	Gamma detection
	Micro-Analyst uR Survey Meter	Supplies liquid as well as plastic scintillators which can be used for a variety of purposes.
Eberline	Model AC-3 ZnS(Ag)	Alpha scintillation probe
	LEG-I NaI(Tl)	Designed for I-125 and for low gamma energy
	PG-2 NaI(Tl)	Low energy gamma and X-ray (needs scaler or ratemeter)
	SAC-4 Alpha Counter	ZnS(Ag) detector
	SAM-2 NaI(Tl)	
	SPA-3 NaI(Tl)	High sensitivity
	SPA-6 NaI(Tl)	Medium sensitivity
EDA Instruments	GRS Series NaI(Tl)	Designed for uranium exploration; very sensitive detectors may be applied to contamination analysis

TABLE B-8 SCINTILLATION DETECTORS (Con't)

VENDOR	MODEL/TYPE	COMMENTS
Johnson and Associates	ASP-2A Gamma Detectors	
	GSP-2A	0.0005 uCi sensitivity (NaI)
	DGSP-2A	I-125 sensitive (NaI)
	GLE - Low Energy Gamma (NaI)	
Ludlum	3-98 Beta/Gamma Detector	Internal GM, external scintillator for iodine
	19 Low Level Gamma Scintillator	0-25 uR/hr low scale
	43-1/2/5/9/10 ZnS(Ag) Alpha Scintillation Detectors	
	44-1 Beta Scintillator/ Gamma Rejection Detector	
	44-2 Gamma NaI(TL) detector	
	44-3 Designed for I-125 and X-Rays (NaI)	
	44-10 Low Level Gamma (NaI)	
	44-11 Gamma Assay (NaI)	
	44-12/14/17/21/22/23/33 NaI Gamma Detectors	
	203/243 Gamma Assay (NaI)	In a shielded well.
Pylon	PMT-GB NaI	5% efficient, 100 cpm/mR/hr
	LEP Low Energy X-Ray and Gamma Probe	28% efficiency, 10 cpm/uR/hr
Scintrex	BGS-3/4 NaI(TL)	Designed for U prospecting. Sensitive enough for contamination counting, 0-20,000 cps

TABLE B-8 SCINTILLATION DETECTORS (Con't)

VENDOR	MODEL/TYPE	COMMENTS
Technical Associates	Stam-2 Alpa Scintillation Probe	
	STG 4/41/41P NaI Scintillation Systems	
Tennelec	LB 5100-PW Alpha/Beta/Gamma (NaI) Detectors	
	NaI(TL) Detectors	Various models
Victoreen	943 NaI Gamma Detector	
	943 Plastic Disc Beta Detector	
	Model 490	Uses GM or scintillator probes, 0-800 cpm low range

TABLE B-9 SEMI-CONDUCTOR DETECTORS

VENDOR	MODEL/TYPE	COMMENTS
Aptec	PHYGE Coaxial Spectometer (Ge) CS Series	Gamma and high energy X-Ray
	PHYGE Planar Spectometer (Ge)	X-Ray and low energy PS series
	PHYGE Charged Particle Spectrometer	Alpha, beta, proton CP series
EG and G	Ortec Silicon Surface Barrier Detectors - Series A, B, E	Particle detection. Designs for specific applications.
Ludlum	Silicon 43-17 Alpha Detector	
PGT	Various Silicon, Ge and GeLi Spectrometers with Coaxial Planar and Well Detectors	
Tennelec	Silicon Surface Barrier Detectors	Several series - no details

TABLE B-10 COUNTING ELECTRONICS (SCALERS/RATEMETERS)

VENDOR	MODEL/TYPE	COMMENTS
Atomic Accessories Ltd.	SR 234 Scaler/Ratemeter	Various detectors
Bicron	Surveyor 50	Various detectors (GM or scintillator) can be attached - EWGM / SWGM TPGM / APGM / PGM GI / GILE
	Labteck Scaler/Ratemeter/Analyzer	GM or scintillation detectors
	Analyst Portable Analyzer	GM or scintillation detectors
Eberline	Portable Model ASP-1 Analog Smart	Detector Probes Recommended: HP-210L 260 AC-3 LEGI SPA
	Model E-120 GM Survey Meter	Probes Recommended: HP-210
	Model E-120E GM Survey Meter	Probes Recommended: HP-260
	Model E-140 GM Survey Meter	Probes Recommended: HP-210 HP-260
	Model E-140N GM Survey Meter	Detectors Recommended: HP-210
	Model E S20 GM Survey Meter	Detectors Recommended: HP-210 HP-260
	Model ESP-1 Smart Portable (ESP-2)	Detectors Recommended: HP-270 HP-210 AC3 LEG-1 SPA-3 SPA-6

TABLE B-10 COUNTING ELECTRONICS (SCALERS/RATEMETERS) (Con't)

VENDOR	MODEL/TYPE	COMMENTS
Eberline	MS-2/3 Mini Scaler	Detectors Recommended: AC-3 HP-190 HP-260 LEG-I SPA 3/6 SAC - RS
	PAC - 4G - 3 Portable Lin-Log Gas Proportional Counter	Detectors Recommended: AC-21 AC-21 B
	PRM-6 Pulse Rate Meter	Detectors Recommended: AC-3 HP-190 HP-210 HP-260 LEG-1 PG-2 SPA-3
	RM-14 Radiation Monitor	Detectors Recommended: HP-190 HP-210 HP-260
	RM-20-1/5 Radiation Monitor	Detectors Recommended: AC-3/7/8 HP-190 HP-210 HP-260 LEG-1 PG-2 SPA-3
	RM-21 Radiation Monitor	Detectors Recommended: AC-3/7/8 HP-190 HP-210 HP-260 LEG-1 PG-2 SPA-3/6
	RM-22 Radiation Monitor	Detectors Recommended: AC-3 HP-190 HP-210 HP-260 LEG-1 PG-2 SPA-3

TABLE B-10 COUNTING ELECTRONICS (SCALERS/RATEMETERS) (Con't)

VENDOR	MODEL/TYPE	COMMENTS
Eberline	SPM-100 Smart Radiation Monitor Ratemeters or Scaler	Detectors Recommended: HP-270 HP-210 AC3 LEG-1 SPA-3
Johnson and Associates	GSM-5/105/15	Survey meter with optional Johnson GM detectors and scintillators
Ludlum	1000/2000/2200/2218/2900/2600/2929 Scalers/Analyzers	Portable survey meters. Detectability of uR fields or low level CPM. Various GM and scintillation probes.
Nuclear Measurements Corp.	DS-33 Decade Scaler	GM, scintillator, proportional detectors
Pylon	Portable Radiation Monitor AB-5	Recommended Probes: SA, SB, SAB LEP, GB
Technical Associates	FB-Series Scalers and Ratemeters	
Victoreen	Model 490	0-150 cpm low range, various detectors can be attached.
	Model 491	0-800 cpm low range, various GM and scintillation probes may be used.
	Universal Digital Ratemeter	942-100 All Victoreen Scintillation Counter 956-100 Victoreen 897 Series GM Tubes

APPENDIX C

SURVEY OF COMPANIES PERFORMING LEAK TEST ANALYSIS

C.1 Summary of the Survey

Seven companies that offer leak testing services were surveyed to obtain information on their equipment and methods. Brief summaries of their methods are given below.

COMPANY A

Samples are ashed on 2" stainless steal planchets. The ash is mixed with a collodion solution in acetone and dried on the planchet with an IR lamp. A gas flow alpha/beta proportional counter is used to count radioactivity for 100 minutes. The limit of detection for gross beta and alpha activity is 40 mBq.

COMPANY B

The source is swabbed with a water-moistened Q-Tip. A 1,000 second count of the activity is taken with a Ge detector (efficiency >20%) and analyzed with a multi-channel analyzer.

Incoming equipment is scanned for contamination using a GM tube and count rate meter.

COMPANY C

Wipe tests are taken with Q-Tips which are surveyed with a Fisher-Research Lab Inc. instrument (scintillator dyne Model 56). This meter is calibrated with a 4.5 nanocurie (167 Becquerel) source. The meter's lowest range is 0-25 counts/sec.

COMPANY D

Wipe tests are taken with Kimwipes moistened with water. The Kimwipe is surveyed with a GM meter set on the 0.0-0.1 Rem/hr scale.

COMPANY E

Test wipes are monitored for beta activity with a liquid scintillation counter. Gamma ray monitoring is done with an unspecified detector.

COMPANY F

Test wipes are taken with styrofoam and monitored with a Berthold Rato/F meter.

COMPANY G

Test wipes are monitored for beta and gamma radiation using a NaI[TL] crystal and either a single channel or multi-channel analyzer. For pure beta emitters, an LSC 2/V scintillator counter from Nuclear Enterprises is used. Liquid scintillation is also used for detection of alpha radiation.

C.2 Conclusions

From this small survey it can be seen that companies performing leak test analysis use a diverse set of instruments and methods.